

## **VEHICLE ROOF**

### **REFERENCE TO RELATED APPLICATIONS**

- [1] The present invention claims the benefit of German Patent Application No. 102 57 398.0, filed December 9, 2002.

### **TECHNICAL FIELD**

- [2] The present invention relates to a vehicle roof having a roof frame and a roof module that permanently and fixedly attached to the roof frame. More particularly, the invention is directed to a vehicle roof having a roof frame with an edge that points inwardly toward the roof module.

### **BACKGROUND OF THE INVENTION**

- [3] Currently available vehicle roof designs are moving away from structures incorporating a sheet metal roof that is welded to a roof frame or configured as an integral part thereof. Newer designs increasingly make use of a roof frame on which a roof module, which is manufactured by a supplier, is permanently and fixedly attached via glue and/or screws or other fasteners. Note that even though the roof is still permanently and fixedly attached, it does not exclude the possibility that the roof module, for purposes of replacement, can be separated from the frame in a workshop and replaced by a new roof module that is again is permanently and fixedly attached to the roof frame.
- [4] In this context, the roof module is customarily made of plastic and has an exterior skin made of, for example, an aluminum or plastic film attached to a foam backing. The roof module must remain attached to the roof frame even in the event of an impact and a heavy deformation of the roof frame. In case of a lateral impact, which may be simulated by a pole impact test, the immediate result is often a deformation of the roof frame. Therefore, great demands are placed on the attachment of the roof module to the vehicle roof.
- [5] There is a desire for an attachment structure that can attach the roof module to the roof frame in a manner that can withstand high impacts regardless of the impact direction.

## SUMMARY OF THE INVENTION

- [6] The invention is directed to a vehicle roof having an improved connection between the roof module and the roof frame. In the case of a vehicle roof of the type described above, the roof module comprises a rigid safety element in its lower side. The rigid element has at least one protruding portion that points to the adjoining edge and that is positioned lower than the adjoining edge. The rigid safety element provides a form-locking latching structure if the roof frame deforms and also reinforces the roof module itself.
- [7] If the roof frame, with its edge pointing inward, (i.e., toward the safety element) is horizontally displaced during a deformation, then the edge moves over the protruding portion of the roof module so that the safety element engages the edge from behind. As a result, the roof module is prevented from lifting off from the roof frame even if the attachment of the roof frame to the roof module is partially destroyed. In the case of a non-deformed roof frame, the protruding portion lies lateral to the edge and therefore does not yet grasp the edge from behind. This enables the roof module to be placed onto the roof frame from above. The safety element, however, is situated almost directly bordering the edge so that the edge caught by the safety element even if a small deformation of the roof frame occurs.
- [8] In one embodiment, the edge is a flange-like, inward-pointing extension of the roof frame. The roof frame is a hollow section, and a thin sheet metal flange protrudes horizontally to the inside and preferably continuously surrounds the hollow section. The flange serves to attach, center and support the roof module. In one embodiment, the sheet metal flange is at the edge of the roof frame, and the safety element engages under the flange if the roof frame deforms.
- [9] The roof module is advantageously fastened to this flange at the edge. In one embodiment, the roof module is fastened to the flange by glue and screw connections. An appropriate adhesive bead may run continuously around the edge in accordance with one embodiment.
- [10] The safety element may be, for example, a sheet metal part.
- [11] According to one embodiment, the safety element is at least partially embedded in a foam backing under the exterior skin of the roof module. This embedding can also be conducted so that the safety element is entirely embedded in the foam backing to anchor the safety element firmly in the foam backing. However, the foam backing does not exert great

resistance against the horizontally displaceable edge when the roof frame deforms, allowing the edge to penetrate into the foam and move over the protruding portion of the safety element, which is situated below the edge.

[12] In one embodiment, the safety element is a hollow section that is open towards the edge of the roof frame. The hollow section receives the edge if there is a horizontal displacement of the edge toward the safety element. If the roof frame deforms, the hollow section provides a form-locking connection in the vertical direction both upwardly and downwardly. In addition, the hollow section transmits force into the foam over a large area and prevents the foam from being split as the edge penetrates into the foam. In one embodiment, the safety element is advantageously a C-profile or a double-T profile, for example.

[13] If the safety element runs around the lower side of the roof module, it can also serve as a reinforcement frame, thereby providing a dual function.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

[14] Further features and advantages of the present invention will be apparent from the following description and the following drawings, to which reference is made and in which:

[15] Figure 1 is a top view of a vehicle roof according to one embodiment of the invention,

[16] Figure 2 is a section view taken along line II-II of the vehicle roof in an area of the connection between a roof frame and a roof module shown in Figure 1; and

[17] Figure 3 is a section view of the area depicted in Figure 2 with a roof frame that has been deformed by a pole impact test.

### **DETAILED DESCRIPTION OF THE EMBODIMENTS**

[18] Figure 1 shows a vehicle roof having a continuously surrounding roof frame 10. A roof frame 10 supports a roof module 12 is placed onto it from above. The roof module 12 and is permanently and fixedly attached to the roof frame, i.e., roof module 12 cannot be displaced with respect to roof frame 10. The roof module 12 may have a roof portion 16 that is closeable by a movable cover 14 so that the roof module 12 can contain an integrated sliding-roof system.

- [19] As shown in Figure 2, the roof frame, which may be made of sheet metal, has a hollow section that is closed, as seen in cross-section. An inwardly-pointing extension protrudes from the hollow section and is in the form of a plate-shaped, horizontal, flange-like edge 20 in this embodiment. The roof module 12 is placed onto the horizontal edge 20 from above. In one embodiment, the horizontal edge 20 advantageously runs continuously around the entire roof frame 10.
- [20] The roof module 12 has an exterior skin 22, which may be a deep-drawn plastic film having a foam backing 24 on its lower side. The foam backing 24 is preferably made of polyurethane foam or a similar material. A seal 26 may be disposed on the exterior edge of roof module 12, the seal 26 being designed to assure a tightly sealed connection of the roof module 12 to roof frame 10. The foam backing 24 in the area of the edge 20 has a groove-like recess 30 in which an adhesive bead 32 is disposed. The adhesive bead 32 may continuously surround the entire edge 20 and secure the roof module 12 to the edge 20. In addition, screws or other fasteners 60 may also secure the roof module 12 to the edge 20.
- [21] As shown in Figure 2, the roof module 12 does not engage the roof frame 10 from underneath the frame 10 at any location, allowing the roof module 12 to simply be placed down onto the edge 20 from above.
- [22] Directly bordering the edge 20, the foam backing 24 has a bead 40 that protrudes downward such that the bead 40 lies lower than the edge 20. In the area of bead 40, a hollow section having, for example, a C-shape or double-T shape 78 that is open to the edge 20 is completely embedded in the foam backing 24. The hollow section constitutes a safety element 50 that, in the event of a collision joins the roof frame to the roof module. A lower leg 52 of the safety element 50 (i.e., one portion of the safety element 50) extends along a plane that is below than the edge 20 and another portion, such as the upper leg 54, of the safety element 50 extends along a plane that is above the edge 20. As can be seen in Figure 2, the safety element 50 does not directly border the edge 20 and instead is designed to catch the edge 20 if deformation of the roof frame 10 and/or roof module 12 occurs. The safety element 50 forms a surrounding reinforcement profile of the roof module 12.
- [23] According to an alternative embodiment, safety element 50 can be fastened only along the side beam of the roof frame 10, i.e., extending only in the vehicle longitudinal

direction. In this embodiment, it is possible in to optionally provide additional connecting braces between the two-sided, rail-shaped safety elements 50.

[24] Figure 3 illustrates the functioning of the safety element 50 during an impact. If a side impact occurs, which may be simulated by a so-called pole impact test, a horizontal, lateral force  $F$  is exerted on roof frame 10. The roof frame 10 is deformed laterally and horizontally, causing its edge 20 to be displaced laterally and horizontally. The edge 20 penetrates into the foam backing 24 and is received between the legs 52, 54 of the safety element 50. Note that it is possible for the edge 20, as a function of the intensity of force  $F$ , to contact a connecting bar 56 connecting the legs 52, 54 of the safety element 50.

[25] If an upwardly-directed force  $K$  is exerted on the adhesive bead 32, bringing the adhesive bead 32 to the limits of its load bearing capability, the roof module 12 will not separate from the edge 20, because the safety element 50 additionally secures roof module 12 in both the upward and downward directions. In addition, a counterforce  $FG$  that counteracts the force  $F$  is exerted by the safety element 50 of the roof module 12. The counterforce increases the stability of the entire roof.

[26] It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention. It is intended that the following claims define the scope of the invention and that the method and apparatus within the scope of these claims and their equivalents be covered thereby.